PROTECTIVE NANOLAYERS ON METAL SURFACES FABRICATED BY LANGMUIR-BLODGETT AND SELF-ASSEMBLY TECHNIQUES

Loránd Románszki, Judit Telegdi, Erika Kálmán
Chemical Research Center of the Hungarian Academy of Sciences, Pusztaszeri út 59-67, 1025 Budapest, Hungary
L.Romanszki@chemres.hu

Microbiological corrosion (MC) is a corrosion process which undergoes in the presence of microorganisms, which, by their chemically aggressive metabolites and sticky biofilm contribute to the deterioration of metals. If one manages to impede the adhesion of the cells and the biofilm-formation, then the MC can be eliminated. Our studies [1-5] concern the inhibition of corrosion of and bacterial cells' adhesion on copper surfaces via protective molecular films of organic compounds, prepared by the Langmuir-Blodgett technique (LB) and self-assembly.

Both LB and self-assembly require amphiphile molecules. Such molecules contain hydrophilic functional groups and hydrophobic chains (see left figure). In our experiments we tried thirteen different amphiphiles, saturated and unsaturated carboxylic and hydroxamic acids. First Langmuir monomolecular films at the air/water interphase have been prepared by spreading the film-forming compounds' solutions in chloroform onto water subphases. The surface pressure vs. area per molecule isotherms have been recorded in each case. Upon analysing these isotherms, the best conditions (i.e. constant pressure, temperature, speed) of film transfer have been defined.

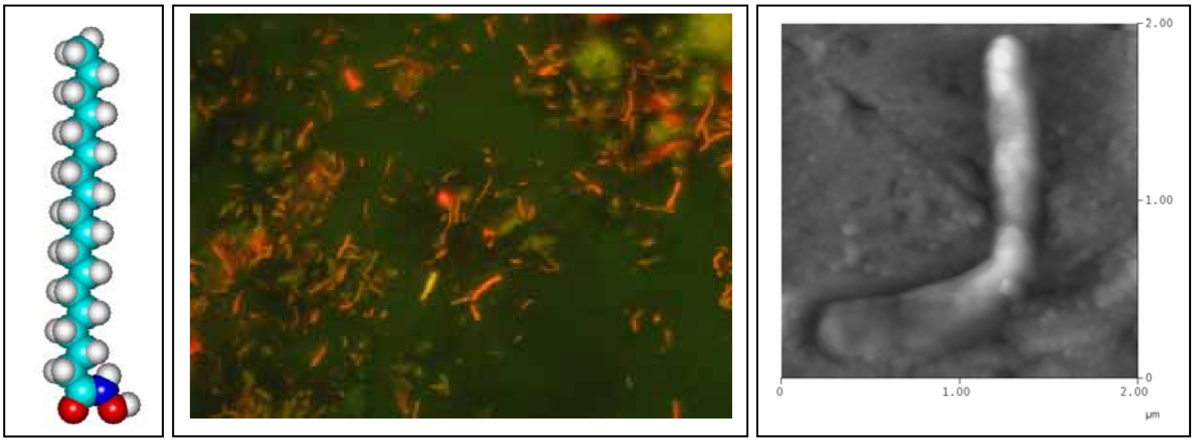
Using these parameters, the Langmuir-films have been transferred onto solid substrates such as mica, glass and copper, as mono- and multimolecular LB-films, as well. The molecular ordering of these LB films has been studied by second harmonic generation spectroscopy (SFS). The spectra revealed high molecular order in the films of the studied saturated compounds, while low ordering degree in the films of the unsaturated amphiphiles. In parallel to the LB-films, films of the amphiphiles have been prepared on polished copper substrates by self-assembly technique too.

Coated copper samples have been immersed for 15 hours in 0.5 M NaCl solution. The corroded surfaces then were investigated by atomic force microscope (AFM). Mean roughness and bearing factors were used to numerically evaluate the deterioration of the surfaces and hence to draw conclusions about the corrosion inhibitive effect of these molecular layers. Results showed the efficiency of the saturated hydroxamic acids.

To investigate the bacterial adhesion inhibitive efficiency of these coatings, treated copper samples were immersed for 48 hours in industrial cooling water containing mixed population of microorganisms. Then the samples were stained with acridine orange and visualized under fluorescence microscope and AFM (see middle and right figures). The two parallel techniques proved the inhibition effect not on the cell adhesion itself, but on the biofilm formation. The number of adhered microorganisms was roughly the same in each case, and seemed to not depend on the applied protective coating. However, a sticky biofilm was detected with the AFM cantilever in the case of unprotected samples, which was absent on the nanofilm-coated surfaces.

References:

[1] J. Telegdi, T. Rigó, E. Kálmán, Corr. Eng. Sci. Technol. **39** (2004) 65.
[2] J. Telegdi, T. Rigó, J. Beczner, E. Kálmán, Surface Eng. **21** (2005) 107.
[3] T. Rigó, A. Mikó, J. Telegdi, M. Lakatos-Varsányi, A. Shaban, E. Kálmán, Electrochem. Solid St. **8** (2005) B51.
[4] J. Telegdi, T. Rigó, E. Kálmán, J. Electroanal. Chem. **582** (2005) 191.
[5] J. Telegdi, H. Otmačić-Ćurković, K. Marušić, F. Al-Taher, E. Stupnišec-Lisac, E. Kálmán, Chem. Biochem. Eng. Q. **21** (2007) 77.



Figures. Left: Molecule model of the stearoyl hydroxamic acid, one of the nanofilm-forming compounds. Middle: Rod-like bacilli on a copper surface imaged under fluorescence microscope after 48 h immersion of the substrate. Right: A dividing bacillus on copper surface (scan area: 2×2 μm^2, z-range: 200 nm)